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BENEFICIATION OF TWO SAMPLES OF ZEOLITE

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BENEFICIATION OF TWO SAMPLES OF ZEOLITE

by

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ABSTRACT

Two samples of zeolite, Sample A from Arizona, U.S.A. and Sample B from Urez, Mexico have been beneficiated by magnetic separation and flotation. Due to the very small weights of head sample, 1.3 kg for Sample A and 1.7 kg from Sample B, no definite conclusions can be drawn with regard to flotation.

A magnetic separation study separated 66.9% of the titanium minerals and 51% of the iron oxide minerals from Sample B . Sample A did not respond as well to magnetic separation as only 35.1% of the titanium minerals and 38.4% of the iron oxide minerals were removed.

It is recommended that any further testwork be conducted on a larger weight of sample.

KEYWORDS: BENEFICIATION, MAGNETIC SEPARATION, FLOTATION, MINERALOGY, ZEOLITE.

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ENRICHISSEMENT DE DEUX ÉCHANTILLONS DE ZÉOLITE

par

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RÉSUMÉ

Deux échantillons de zéolite (échantillon A de l'Arizona et échantillon B d'Urez au Mexique) ont été enrichis par séparation magnétique et par flottation. En raison du très petit poids des échantillons de concentré, soit 1,3 kg pour l'échantillon A et 1,7 kg pour l'échantillon B, aucune conclusion définitive ne peut être tirée en ce qui concerne la flottation.

Une étude de séparation magnétique a permis de séparer 66,9 % des minéraux de titane et 51 % des minéraux d'oxydes de fer à partir de l'échantillon B. L'échantillon A n'a pas réagi aussi bien à la séparation magnétique puisque seulement 35,1 % des minéraux de titane et 38,4% des minéraux d'oxyde de fer ont été enlevés.

Il est recommandé de procéder aux éventuels travaux d'essai sur un plus gros poids d'échantillon.

Mots-clés: enrichissement, séparation magnétique, flottation, minéralogie, zéolite.

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INTRODUCTION

In July 1986, two samples of zeolite were delivered to the Non-Metallic Minerals Section for beneficiation studies to remove impurities. Sample A was reported to be from Horseshoe Dam, Arizona and Sample B from Urez, Mexico.

It was understood that any successful beneficiation process established with Samples A and B, would form the basis for a more detailed cost recovery study on a Canadian source of zeolite.

SAMPLE DESCRIPTION

Sample A: ≈ 1.3 kg of light buff coloured -25 mm material
Sample B: ≈ 1.7 kg of buff coloured -150 µm material

HEAD ANALYSIS

Oxide type	Sample A	Sample B
SiO_2	66.7	62.01
TiO_2	0.2	0.17
Al_2O_3	10.3	12.76
Fe_2O_3	1.86	1.54
MgO	2.00	0.95
CaO	2.58	3.30
Na_2O	0.40	2.51
K_2O	2.37	2.62
LOI	12.3	13.95

MINERALOGY

Sample A: Based on the colour and the high silica analysis it would appear that the variety of zeolite present is heulandite:

$$2CaO.2Al_2O_3.14SiO_2.12H_2O.$$

Heulandite is the only variety which gives an analysis > 60% SiO_2. The impurities, estimated to be < 5%, include glass shards, limonite, magnetite and phlogopite mica.

Sample B. Based on the colour and the high silica analysis it would appear that the variety of zeolite present is also heulandite. The impurities present, which account for ≈ 10% of the sample, are silica, oligoclase, biotite, magnetite, hornblende, volcanic glass and limonite.

PROCESSING

Because each sample weighed less than 2 kg, the scope of processing was limited to small scale bench testwork. Hornblende, biotite and iron oxide minerals were separated by magnetic separation and the mica by flotation.

Head Sample

The liberation size of the impurities from the zeolite was determined by sizing a ground product and analysing each size fraction for SiO_2, Al_2O_3, Fe_2O_3 and CaO.

A representative portion of Sample A was stage crushed to 2.4 mm. Stage crushing was necessary to minimize the production of fine material, since Sample A was soft and easily broken. The crushed sample was sized from 2.4 mm to 100 µm by dry sieving. Further sizing of the -100 µm fraction was conducted by wet sieving on a 44 µm sieve and then passing a portion of the -44 µm fraction through a laboratory cyclosizer which sized down to 10 µm. The size analysis together with the product balance is reported in Table 1.

The fine size of Sample B suggested that the sample had been previously ground. Sizing of this sample was conducted by wet sieving on a 44 µm sieve with dry sieving of the +44 µm fraction. Further sizing of the -44 µm fraction was conducted by passing a portion through the cyclosizer. The size analysis together with the product balance is reported in Table 2.

Magnetic Separation

100 g portions of Sample A and B were passed through the Sala high intensity magnetic separator to remove hornblende, biotite and iron oxide minerals. Two tests were conducted on each sample at different flow rates in an attempt to obtain maximum separation of iron minerals, with minimum

loss of zeolites. The flow rates and magnetic field strength values are reported in Table 3, product balances are reported in Table 4.

Flotation

Due to the small quantity of each sample, only one flotation test with Sample A and three flotation tests with Sample B were conducted. The approach to flotation was reverse flotation of the alumino-silicate minerals using Armac T (tallow amine acetate) collector in an acid pH medium, with sodium silicate to depress silica. Flotation was conducted on 500 g lots at 30% solids using a 1.1 L flotation cell. A summary of the parameter data and reagent concentration data is reported in Table 5 and the product recovery balances in Table 6.

RESULTS

When considering the product balance for Sample A, apart from a reduction of the iron oxide analysis in the -30 μm range, the alumina, silica and alkali oxides show no variation with decreasing size. This would imply that the iron oxide minerals concentrate in the coarser sizes and the zeolites are evenly distributed throughout the entire size range from 2.5 mm to 10 μm.

Sample B had previously been ground, so that the distribution of iron oxide minerals in the coarser sizes could not be determined. The most marked trends were an increase in the alkali oxide content with decreasing size. This would imply the presence of carbonate minerals in the finer sizes.

The results of magnetic separation indicate that Sample A did not respond, as only 35.1% of the titanium minerals and 38.4% of the iron oxide minerals were removed in 24.4% of the sample weight. A low brightness value of 57.3 for the non-magnetic fraction also demonstrates the inability to remove magnetic materials. While the loss of zeolites in the magnetic fraction cannot be ascertained by chemical analysis, the high silica content of the magnetic fraction, 66.1% SiO_2 would imply an appreciable loss.

Sample B responded better to magnetic separation, 66.9% of the titanium

minerals and 51.0% of the iron oxide minerals were removed in 22.8% of the weight. The brightness value of the non-magnetic fraction was correspondingly higher at 67.3. As with Sample A the high silica analysis of the magnetic fraction, 65.8% SiO_2 would imply an appreciable loss of zeolites.

Flotation was inconclusive for both samples. For Sample A the removal of iron oxides was slightly better at 43.1%, than with magnetic separation at 38.4%. The high silica analyses of the rougher floats would imply loss of zeolites. With Sample B an increase of the silica content of Test 2 to 70.8% SiO_2 implies a concentration of zeolite. It may be significant that this test was deslimed before flotation.

Brightness values of concentrated zeolite products (rougher tailings) averaged only 59 for each sample.

CONCLUSIONS

Very little conclusive data can be obtained from either Sample A or B due to the very small quantity of each head sample. Sample B responded better to magnetic separation than did Sample A, but the loss of zeolite in the magnetic fractions could not be accurately determined.

Reverse flotation of impurities from the zeolite was inconclusive for both Samples A and B.

REMARKS

To accurately determine the degree to which zeolite from these two deposits or any other deposit can be concentrated, it would be necessary to study a much larger sample. A minimum of 25 kg is required to conduct beneficiation studies which would include mineralogy as well as beneficiation techniques.

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Table 1 - Head size analysis and product balance for Sample A

Sieve Analysis µm	Wt %	Analysis %					Distribution %				
		Al_2O_3	Fe_2O_3	SiO_2	MgO	CaO	Al_2O_3	Fe_2O_3	SiO_2	MgO	CaO
-2500, +1400	25.4	10.0	1.98	65.0	1.73	2.54	24.9	25.7	24.9	24.8	24.5
-1400, +1200	0.8	10.2	2.03	65.9	1.83	2.55	0.8	0.8	0.8	0.8	0.8
-1200, + 910	9.8	10.2	2.03	66.6	1.80	2.57	9.8	10.0	9.8	9.9	9.6
- 910, + 600	7.5	10.3	2.01	66.0	1.82	2.57	7.6	7.7	7.4	7.8	7.3
- 600, + 425	5.0	10.3	2.05	65.9	1.82	2.61	5.1	5.3	5.0	5.2	5.0
- 425, + 300	3.4	10.3	2.03	65.8	1.83	2.61	3.4	3.5	3.4	3.5	3.4
- 300, + 200	2.7	10.3	1.97	67.2	1.78	2.59	2.7	2.8	2.7	2.8	2.7
- 200, + 160	2.2	10.6	1.98	67.2	1.87	2.68	2.3	2.3	2.2	2.3	2.2
- 160, + 100	2.6	10.4	2.31	68.3	2.00	2.53	2.6	3.1	2.7	2.9	2.5
- 100, + 44	7.8	10.7	1.38	66.1	1.71	2.77	8.2	5.5	7.8	7.5	8.2
- 44, + 31	0.9	11.1	1.32	63.8	0.98	2.43	1.0	0.6	0.9	0.5	0.8
- 31, + 22	4.1	11.4	0.71	65.9	1.07	2.70	4.6	1.5	4.0	2.5	4.2
- 22, + 14	6.8	10.8	0.87	68.6	1.20	2.72	7.2	3.0	7.0	4.6	7.0
- 14, + 11	6.9	10.9	0.81	69.0	1.18	2.74	7.4	2.9	7.2	4.6	7.2
- 11,	14.1	8.98	3.51	67.0	2.55	2.72	12.4	25.3	14.2	20.3	14.6
Head calculated	100	10.20	1.95	66.42	1.77	2.63	100.0	100.0	100.0	100.0	100.0

Table 2 - Head size analysis and product balance for Sample B

Size (µm)	Wt %	Analysis %					Distribution %				
		Al_2O_3	Fe_2O_3	SiO_2	MgO	CaO	Al_2O_3	Fe_2O_3	SiO_2	MgO	CaO
-200, +100	6.9	11.8	1.02	71.7	0.32	1.11	6.1	5.3	7.5	3.1	2.5
-100, + 71	5.9	11.7	1.28	64.5	0.38	1.53	5.2	5.7	5.7	3.1	3.0
- 71, + 45	9.8	12.9	1.41	71.6	0.39	1.73	9.4	3.0	10.6	5.2	5.6
- 45, + 25	15.3	13.3	1.52	69.5	0.42	2.10	15.3	17.5	16.1	8.8	10.6
- 25, + 18	4.0	13.6	1.06	68.6	0.47	2.71	4.0	3.2	4.1	2.6	3.6
- 18, + 11	4.9	13.4	1.19	65.9	0.62	3.16	4.9	4.4	4.9	4.1	5.1
- 11, + 8	4.4	13.6	1.17	65.2	0.75	3.70	4.5	3.8	4.3	4.5	5.4
- 8,	48.8	14.1	1.58	64.6	1.04	4.04	50.6	57.1	46.8	68.6	64.2
Head calculated	100	13.37	1.33	66.25	0.73	3.02	100.0	100.0	100.0	100.0	100.0

Table 3 - Physical variables for magnetic separation tests

Test no.	Sample	Magnetic intensity k/gauss	Feed rate min./sec.
1	B	21.4	155
2	B	21.4	80
3	A	21.4	80
4	A	21.4	55

Table 4 - Product balances for Sala magnetic separation tests

Test no.	Sample	Products	Wt %	Analysis %						Distribution %					
				Fe_2O_3	CaO	SiO_2	Al_2O_3	MgO	TiO_2	Fe_2O_3	CaO	SiO_2	Al_2O_3	MgO	TiO_2
1	B	Sala mags	31.7	2.79	2.74	64.7	13.3	0.85	0.35	57.7	24.5	31.6	31.9	36.0	71.6
		Sala non-mags	68.3	0.95	3.92	64.9	13.2	0.70	0.06	42.3	75.5	68.4	68.1	64.0	28.4
		Head (calculated)	100.0	1.53	3.54	64.8	13.2	0.75	0.16	100.0	100.0	100.0	100.0	100.0	100.0
2	B	Sala mags	22.8	3.10	2.64	65.8	13.6	0.87	0.41	51.0	17.2	22.9	23.3	27.1	66.9
		Sala non-mags	77.2	0.88	3.76	65.6	13.2	0.69	0.06	49.0	82.8	77.1	76.7	72.9	33.1
		Head (calculated)	100.0	1.39	3.51	65.6	13.3	0.73	0.14	100.0	100.0	100.0	100.0	100.0	100.0
3	A	Sala mags	18.1	2.91	2.80	65.4	9.83	2.45	0.25	30.0	18.9	18.3	17.7	23.3	26.8
		Sala non-mags	81.9	1.50	2.66	64.6	10.1	1.78	0.15	70.0	81.9	81.7	82.3	76.7	73.2
		Head (calculated)	100.0	1.76	2.68	64.7	10.1	1.90	0.17	100.0	100.0	100.0	100.0	100.0	100.0
4	A	Sala mags	24.4	2.86	2.75	66.6	10.0	2.46	0.25	38.4	24.9	25.3	24.6	31.0	35.1
		Sala non-mags	75.6	1.48	2.68	63.3	9.9	1.77	0.15	61.6	75.1	74.7	75.4	69.0	64.9
		Head (calculated)	100.0	1.82	2.70	64.1	9.9	1.94	0.17	100.0	100.0	100.0	100.0	100.0	100.0

Table 5 - Flotation parameter data and reagent concentration

Test no.	Sample	Flotation stage	No. of stages	Cond. time min.	Float time min.	pH	Pulp density %s	Impeller speed r.p.m.	Collectors Armac T g/t	Na_2SiO_3 g/t	H_2SO_4 kg/t	Dow-200 g/t
1	B	Rougher	2	6	9	4.01	30	1300	210.0	-	19.29	99.4
2	B	Rougher	2	6	10	2.01	30	1300	263.8	-	55.07	93.5
3	A	Rougher	2	10	10	6.00	30	1200	204.0	2040.8	10.14	96.4
4	A	Rougher	3	1	11	5.72	30	1200	322.2	3221.1	2.53	304.6

Table 6 - Product balances for flotation tests

Test no.	Sample	Products	Wt %	Analysis %						Distribution %					
				Fe_2O_3	Al_2O_3	SiO_2	CaO	MgO	TiO_2	Fe_2O_3	Al_2O_3	SiO_2	CaO	MgO	TiO_2
1	B	1st rgh. float	12.2	1.96	13.6	63.3	3.01	1.01	0.15	14.9	12.0	11.5	15.7	18.6	11.4
		2nd rgh. float	6.7	2.05	13.7	63.1	3.03	1.05	0.15	8.6	6.7	6.3	8.6	10.5	6.3
		Rgh. tails*	81.1	1.51	13.8	68.3	2.19	0.58	0.16	76.5	81.3	82.2	75.7	70.9	82.3
		Head (calculated)	100.0	1.60	13.8	67.3	2.34	0.66	0.16	100.0	100.0	100.0	100.0	100.0	100.0
2	B	Slime	30.3	1.85	13.9	63.0	4.60	1.25	0.19	37.6	30.9	28.1	48.0	42.8	36.0
		1st rgh. float	8.4	2.06	14.1	66.2	2.76	1.29	0.20	8.0	6.0	5.6	5.5	8.5	7.5
		2nd rgh. float	5.8	2.17	14.0	66.0	2.80	1.34	0.17	5.8	4.2	3.9	3.9	6.1	4.3
		Rgh. tails*	85.5	1.21	13.4	70.8	2.06	0.63	0.14	48.6	58.9	62.4	42.6	42.6	52.2
		Head (calculated)	100.0	1.49	13.6	68.0	2.90	0.89	0.16	100.0	100.0	100.0	100.0	100.0	100.0
3	B	1st rgh. float	12.3	1.78	14.0	64.3	3.51	1.07	0.15	14.2	12.6	11.8	14.3	16.1	11.8
		2nd rgh. float	10.7	1.82	13.5	62.0	3.40	1.09	0.15	12.7	12.1	11.5	13.9	16.5	11.8
		Rgh. tails*	77.0	1.46	13.4	66.3	2.81	0.71	0.15	73.1	75.3	76.7	71.8	67.4	76.4
		Head (calculated)	100.0	1.53	13.70	66.6	3.01	0.81	0.15	100.0	100.0	100.0	100.0	100.0	100.0
4	A	1st rgh. float	21.6	2.32	9.89	66.1	2.48	2.29	0.21	28.0	20.8	21.6	21.5	25.7	24.9
		2nd rgh. float	3.6	3.75	8.86	66.7	2.17	2.10	0.30	7.6	3.1	3.6	3.2	3.9	6.1
		3rd rgh. float	3.6	3.72	9.03	66.9	2.27	3.21	0.30	7.5	3.2	3.6	3.3	6.0	6.0
		Rgh. tails*	71.2	1.43	10.5	66.2	2.52	1.75	0.16	56.9	72.9	71.2	72.0	64.4	63.0
		Head (calculated)	100.0	1.79	10.25	66.2	2.49	1.93	0.18	100.0	100.0	100.0	100.0	100.0	100.0

* Concentrated zeolite product